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CONTROL OF AN INFESTATION OF THE DOUGLAS-FIR TUSSOCK MOTH WITH DDT AERIAL SPRAY CALAVERAS AND TUOLUMNE COUNTIES, CALIFORNIA

by Robert E. Stevens

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Agriculture--Forest Service, Berkeley, California

U. S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE
CALIFORNIA FOREST AND RANGE EXPERIMENT STATION
Division of Forest Insect Research

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Introduction

On July 31 and August 1 and 2, 1956, the U. S. Forest Service carried on an aerial spraying operation for the control of the Douglas-fir tussock moth, Hemerocampa pseudotsugata McD., in portions of California's Calaveras and Tuolumne Counties. The treated area amounted to some 9,560 acres, and included Federal, State, and private lands. Technical aid on the entomological phases of the project was furnished by the California Forest and Range Experiment Station; this report deals primarily with that part of the job.

The infestation area consisted of seven units strung out in a 35-mile chain roughly paralleling the crest of the Sierra Nevada range, at about the 5,000-ft. level. The general location of these units is indicated in figure 1.

The Douglas-fir tussock moth is a pest of Douglas-fir and white fir; Douglas-fir is scarce in the infestation area, however, and white fir may be considered to be the only host in this instance. The larvae feed on the new foliage, causing growth reduction and, where defoliation is complete, tree mortality. White fir attains large size in the central Sierra and is an important timber species. Figure 2 shows tussock moth defoliation in a typical white-fir stand.

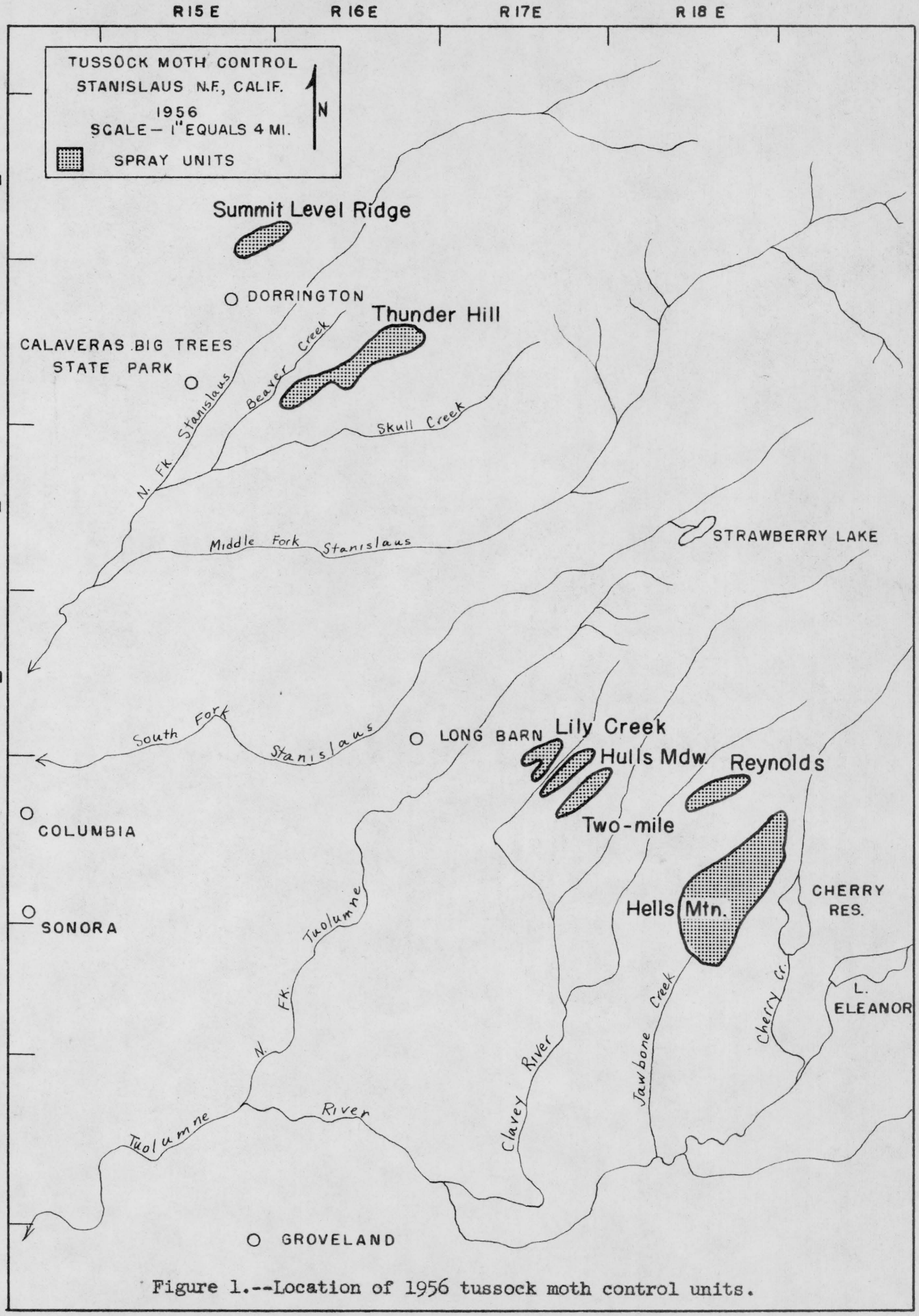

Figure 1.--Location of 1956 tussock moth control units.

Figure 2. White-fir stand severely defoliated by tussock-moth feeding.

The tussock moth is not new to California. In the mid-thirties it became epidemic on the Inyo and Mono National Forests, causing heavy damage to white fir on a number of areas.1/ Entomologists at that time thought the insect to be Oslar's tussock moth, H. oslari Barnes, but recent determinations have indicated that H. pseudotsugata McD. is the correct name. The Inyo epidemic subsided in the late thirties, and little more was noted of the activities of the insect until 1954, when damage was reported near Dorrington, Calif., and from Dew Drop, east of Jackson. The 1954 reports were investigated by a Station entomologist, who felt then that the infestation was dying out. No further damage has been seen in the Jackson area, although light damage was again found near Dorrington in 1955.

1/ Patterson, J. E. Tussock moth, Hemerocampa oslari: Preliminary examination of infested areas on the Inyo and Mono N.F., Calif. June 13-15, 1937. BEPQ, Berkeley, Calif. Memo report.

Preliminary Surveys

Early in August 1955, the Experiment Station received a report of defoliator damage in the Crane Meadows area, and an appraisal survey was made immediately thereafter.[2/] Heavy defoliation was found during the initial reconnaissance, and extensive ground and aerial observations were then made to determine the extent and intensity of the damage. The main body of the infestation, covering some 5,000 acres, was found to be on Cherry Ridge, directly west of the new Cherry Reservoir, adjoining the northwest corner of Yosemite National Park. This block, in addition to being the largest, also suffered the heaviest defoliation. Other outbreaks delineated at the time included two small areas directly north of the main infestation and another somewhat larger one in the vicinity of the Calaveras Big Trees State Park.

Defoliation was heaviest on the ridge tops and negligible in the valleys. The over-all intensity of defoliation showed considerable variation; in the lightest areas, it was hardly noticeable. In some of the heavier areas, however, it was severe enough to kill many mature trees and countless saplings and pole-size trees. Many trees that were not completely killed were top-killed. It is questionable whether these trees will ever regain normal growth, and in their weakened condition they are also unusually susceptible to attacks from the fir engraver, Scolytus ventralis Lec.

In 1955, several factors promoted optimism that the trend of the epidemic would be downward. North of Dorrington, where the 1954 population had been heavy, survey crews could find little 1955 feeding. This observation, along with the disappearance of the Jackson infestation and coupled with the knowledge that epidemics of defoliating insects often experience a rapid decline, brought the hope that perhaps applied control would not be needed. Plans were made, however, to keep close watch on events the following spring.

In early May 1956, egg-mass collections were made from what areas could be reached, to get some indication of the success of the overwintering population. Snow restricted travel, but samples were obtained from Cherry Ridge and the Calaveras Big Trees area. The egg masses were force-reared by being placed in Petri dishes beside a window in the laboratory. An excellent hatch resulted, indicating that another season of heavy defoliation might well be expected.

2/ Trostle, G. C. Douglas-fir tussock moth, Crane Meadows and Thunder Hill Areas, Stanislaus N.F. Fall 1955. Appraisal Survey, CF&RES, Berkeley, Calif. Feb. 15, 1956 (Processed)

Upon receipt of this information, the U. S. Forest Service and several of the private timberland owners expressed interest in controlling the outbreak. An intensive aerial appraisal was then made, which resulted in some modification of the 1955 units, involving more accurate boundary delineation and the inclusion of three small additional units. Medium and heavily defoliated areas were all that could be clearly defined from the air at this time, and as the light areas were not considered to warrant control, no effort was made to outline them.

A ground cruise followed the aerial appraisal, to check on the accuracy of the boundaries delineated from the air. Lines were run at right angles across the ridges, at 1/2-mile intervals, and the same criteria of medium and heavy 1955 defoliation were used in these ground checks as in the aerial survey. Very few boundary changes were found to be necessary as a result of this survey, and the control units were established as follows:

Unit	Acreage
Hells Mountain	5,900
Reynolds	450
Two-mile	460
Hulls Meadow	500
Lily Creek	350
Thunder Hill	1,500
Summit Level Ridge	400
	9,560

Control Plans

A cooperative project was organized, involving the California State Division of Forestry, the California Region of the U. S. Forest Service, and the California Forest and Range Experiment Station. The State Board of Forestry established a zone of infestation, enabling the State to aid in paying control costs on private lands. Further administrative details were taken care of as follows: the State made all agreements and financial arrangements with private timberland owners; the Forest Service handled administration of the spray operation; and the Experiment Station, through its Division of Forest Insect Research, furnished the necessary technical assistance.

Procurement of materials and services was handled by the Forest Service, and included arrangements for formulation, transportation, and storage of insecticide; transfer of insecticide into aircraft; spraying; communications; and airport facilities. Columbia, Calif., was determined to have the only satisfactory airport in the vicinity of the infestation, and operations were centered there. An aerial spray of DDT was recommended, to be applied at the rate of 1 lb. of the insecticide in 1 gallon of solvent and diesel oil per acre. This spray had been effective against the tussock moth in Idaho in 1947,3/ and was expected to be similarly successful in this case. Insecticide was procured in two lots: 2,530 gallons in 55-gallon drums from the California Spray Chemical Company, and 7,580 gallons in tanker-trailers from the Stauffer Chemical Company. Both lots were delivered as finished spray to the airport at Columbia and the tankers were left for storage. The Stauffer lot was analyzed by the Division of Insecticide Investigations, Agricultural Research Service, Yakima, Wash., and found to contain 1.0 lbs. of DDT per gallon of spray. Equipment to meter and transfer the spray into the aircraft was provided by the spray contractor, United-Heckathorn Company, Richmond, Calif. The aircraft used was a converted B-18 bomber, capable of carrying up to 1,400 gallons of insecticide per load. The spraying system consisted of twin pumps working off the aircraft hydraulic system, which forced the insecticide out through a boom extending under approximately three-fourths of the wing. The boom was fitted with 34 Vee Jet 3/8 U50120 nozzles; it is illustrated in figure 3.

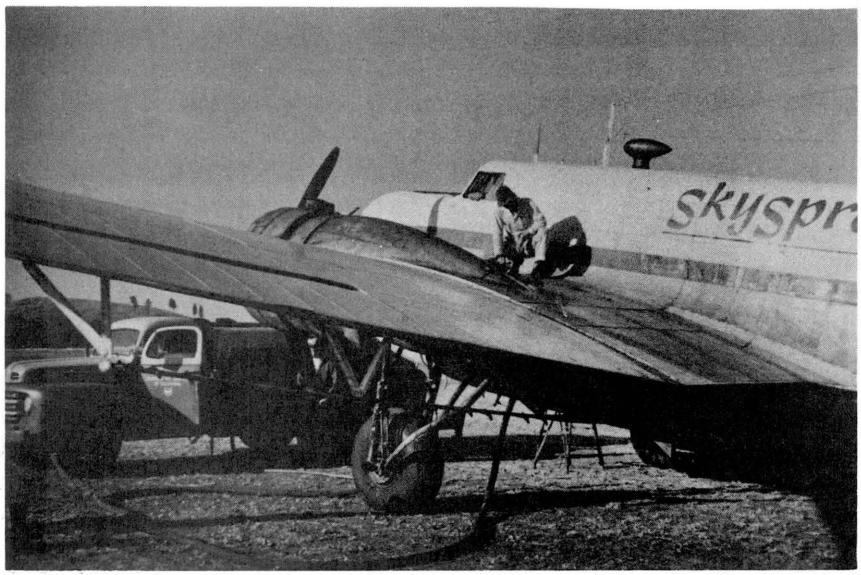

Figure 3. View of spray boom on United-Heckathorn B-18 spray aircraft.

3/ Evenden, J. M., and Jost, E. J. Tussock moth control, North Idaho, 1947. Sponsored by Potlatch Tbr. Protec. Assoc., Idaho State Forestry Dept., U.S. Forest Serv., U.S. Dept. Agr. Bu. Ent. and Plant Quar. Report. (Processed)

Measuring Effects of Spraying

When the work plan for technical assistance was being drawn up,[4/] devising a satisfactory sampling method to assess the effects of control proved to be particularly difficult. This was mostly because of the variation in the density of the tussock moth larval population; only in some of the heaviest areas were there sufficient larvae at practical heights for sampling. However, there was often evidence of current (1956) feeding at eye-level, and observations in the heavier areas indicated that this feeding damage could be generally correlated with the relative abundance of larvae.

Consequently, it was decided to measure the effects of spraying by this method, comparing precontrol damage with postcontrol damage for an indication of the population reduction. This technique gives only general information at best, but appeared to be the only practical answer under the circumstances. Accordingly, the following degrees of current defoliation were established:

0 - no feeding

Light - up to 25% of the new growth fed upon

Medium - 25%-50% of the new growth fed upon

Heavy - over 50% of the new growth fed upon

The precontrol survey was conducted July 24, 25, and 26, 1956. Samples were taken along the ridgetops, at 5-chain intervals. At each stop one 14" branch from each of 4 easily-reached trees was examined, and the degree of defoliation recorded. These data were then weighted on the basis of 1 point for each degree for each tree per sample. Thus a 4-tree sample with four "0" ratings would be given a value of 4 - the lightest possible. Three "lights" and a "medium," for example, were given a value of 9. Weighted figures for each unit were then averaged. This information is compared with that from the postcontrol survey in table 2.

To check spray distribution, oil-sensitive cards of the usual type were laid out in each unit the day before spraying. These cards change color where hit by oil, and an indication of droplet size and number can be obtained by examining them following spraying. The cards were

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4/ Stevens, Robert E. Work plan for station phases of tussock moth control, Stanislaus National Forest, Calif. July 5, 1956. Processed. CF&RES, Berkeley, Calif.

placed 5 chains apart in lines of varying number, at right angles to the expected swath. They were retrieved several hours after spraying; the results indicated by these cards are shown in table 1.

Inasmuch as the postcontrol survey was not to be conducted for a number of weeks following spraying, dropcloths were also set out in two of the areas of heaviest damage to show whether the spray killed any of the caterpillars.

Spray Operations

Pilot orientation

The spray plane arrived at Columbia on July 30, and the pilot and co-pilot were taken on an orientation flight over the control areas. It was felt that defoliation was generally visible enough to preclude the marking of most of the boundaries. On this trip, however, several of the less distinct boundaries were marked with 400-foot rolls of 1/2" aluminum foil. It was thought that this material, which under favorable circumstances can be seen up to 5 miles, would be helpful. Much of it seemed to become lost among the tree crowns, though, and in general it seemed to be of little value. When the pilots got up in the air by themselves, they found considerable difficulty first in even locating the spray blocks and second in determining the location of the boundaries; consequently it was necessary for Forest Service personnel familiar with the area to ride along in the aircraft during spraying and direct the pilots personally. The terrain in much of the area lacks distinctive features and orientation is difficult even for persons with considerable flying experience.

Checking of spray equipment

The spray distribution characteristics of the aircraft were checked at the Columbia airport on the evening of July 30. This was accomplished by placing a line of 42 oil-sensitive cards on the ground at 15-foot intervals. The aircraft then made a spray run at the normal spraying altitude, at right angles to the line of cards. In this manner skips in the distribution, irregularities in droplet size, or other malfunctions of the spraying equipment could be detected. A highly satisfactory swath of 500-foot effective width was produced, along with good droplet size and distribution. This was not particularly surprising, though, inasmuch as the aircraft had just been returned from Montana, where it had been carefully prepared and used on height-of-flight experiments made in conjunction with spruce budworm control.

Spraying

Observations of larval development, both in 1955 and 1956, indicated that spraying could probably be done any time up to the middle of August. All preparations had been made by July 30 and spraying began the next morning. Spraying was done from dawn until about 9:00 a.m. on July 31 and August 1 and 2. Larvae were about three-fourths grown and weather conditions were ideal. The aircraft made 4 trips each morning, carrying about 800 gallons per load. Radio communication was available at the time of spraying between each spray block, the base, and the aircraft; this service provided by Stanislaus National Forest personnel was of great value to the success of the job.

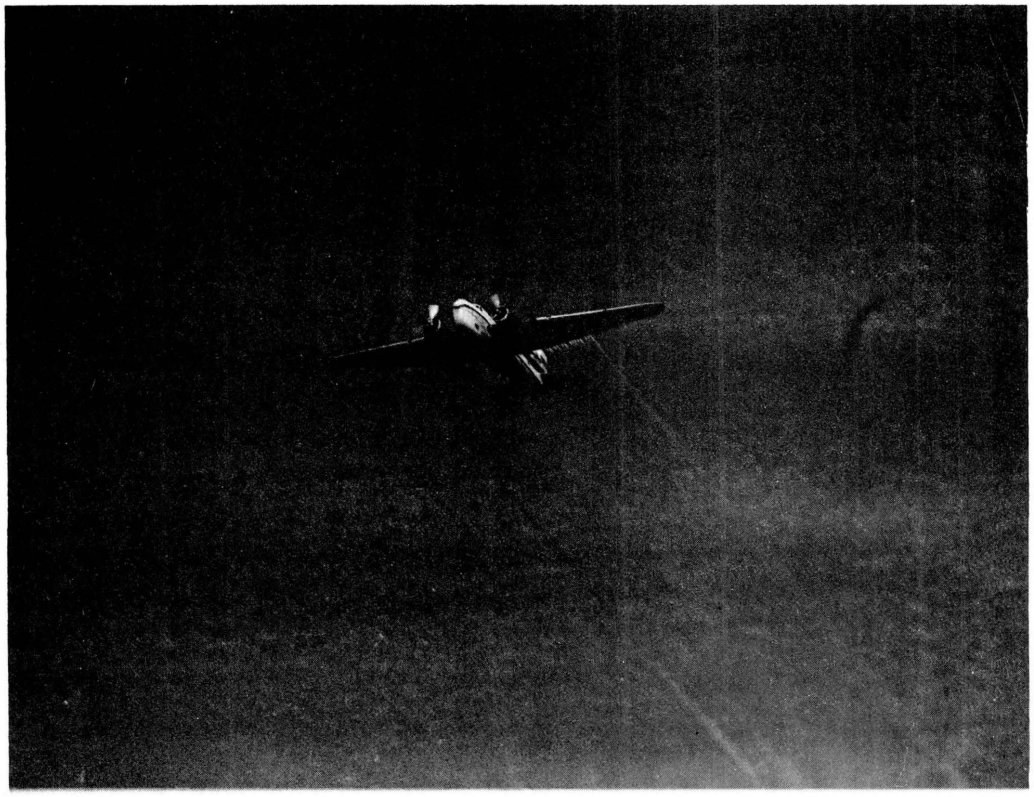

Figure 4. United-Heckathorn B-18 spray plane in operation.

Results

General spray coverage is shown in table 1.

Table 1.--Spray coverage as indicated by oil-sensitive cards

Area	No. of cards set out	Sprayed	Not sprayed
Summit Level Ridge	35	15	20
Thunder Hill	56	39	17
Lily Creek	25	23	2
Hulls Meadow	43	39	4
Two-mile	inaccessible - not checked		
Reynolds	25	24	1
Hells Mountain	67	59	8

The Summit Level Ridge and Thunder Hill units did not receive as good coverage as did the others. An additional run was made over Summit Level Ridge, but inasmuch as the missed cards on Thunder Hill represented only one line in a relatively light area, no re-spraying was done there. Additional coverage was also given the Reynolds Creek unit, for while the extent of coverage was good, a low volume was indicated. The Reynolds Creek unit, while small, suffered some of the heaviest defoliation in 1955, and the 1956 population was similarly heavy.

Dying larvae began falling into the dropcloths within a few hours after being sprayed. In areas where populations were heavy, dead larvae could also be found in the duff and in cobwebs along tree trunks and in brush. No living larvae could be found one day after spraying on a portion of the Lily Creek unit where the pre-spray population was relatively heavy.

The postcontrol appraisal survey was made on October 19, 20, and 21, 1956. It was conducted in the same manner as the precontrol appraisal, along the same strips, and with about the same personnel. The intensity classes were again weighted, and were then compared with the precontrol survey figure. Both surveys are summarized in table 2.

Results

General spray coverage is shown in table 1.

Table 2.--Tussock moth - precontrol and postcontrol surveys

Unit	No. samples		Weighted values		Average		Rating*	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Summit Level Ridge	25	34	146	253	6	7	Light	Light
Thunder Hill	63	62	310	286	5	5	"	"
Lily Creek	18	34	137	242	8	7	"	"
Hulls Meadow	33	32	230	201	7	6	"	"
Two-mile	inaccessible						Very light	
Reynolds	spot checks						Medium	Medium
Hells Mountain - 1	18	17	147	113	8	7	Light	Light
2	35	36	192	157	6	4	"	"
3	32	26	316	225	10	9	Medium	Medium

*4-8 points, light; 9-12 medium; 13-16 heavy.

While the Two-mile unit has not been ground-checked since early summer, low-level aerial reconnaissance in October failed to reveal any evidence of 1956 damage. In general, then, no significant increase in damage was noted after spraying. Using this survey technique under circumstances in which no additional damage had occurred, under ideal conditions the weighted values should remain about the same. However, it can be seen that an actual improvement is indicated in most instances. This is probably an observational error caused by the smoothing out of the needles that were being chewed off at the time of the precontrol appraisal.

In addition to checking defoliation, survey personnel searched for new egg masses which would indicate that some of the insects developed successfully to the adult stage and subsequently oviposited. None were found on any of the spray units. These observations taken together indicate that the spraying was highly successful.

Discussion

This was the first successful large-scale aerial-spray operation for forest insect control in California. We were fortunate in having at our disposal aerial-spray techniques which have been developed during the past 9 years; had this information not been available, the task would have been much more difficult. We were also fortunate in being able to obtain the services of an experienced spray contractor. The efficiency of the United-Heckathorn Company representatives aided materially in carrying out the project safely, successfully, and in the shortest possible time. On the basis of the surveys conducted, it appears that the epidemic populations of 1955-56 have been reduced to an insignificant level, and it is thought that no new defoliation should appear during 1957.

In the most heavily hit area, north of Jawbone Saddle on the Hells Mountain unit, a timber sale was in progress. This situation allowed re-marking and salvage of many dying and top-killed white firs, utilizing thousands of board-feet of timber that would otherwise have been lost. Fortunately, damage was generally lighter elsewhere, and while in these other areas considerable growth reduction will undoubtedly still result, outright tree-killing was prevented.

A study has been set up to follow the effects of tussock moth defoliation. Trees in varying defoliation classes have been tagged and their characteristics recorded. They will be observed annually for a minimum of 5 years, and growth reduction, mortality, and causes of mortality will be noted.

A number of valuable lessons have been learned as a result of this infestation and the resultant control work. As is often the case, there were a number of details which might have been handled more effectively, and possibly it is of some value to discuss several of these in this report.

Spray-unit delineation

This was probably the most obvious deficiency encountered in the project. Much of the foothill country lacks distinctive topography, and several of the spray units were so small that the pilots found difficulty even in locating them. When the units were found, the boundaries were not of such a nature that the pilots were able to recognize them. Several possible remedies appear to be indicated:

Use of aerial photos.--These were not used in this operation, as they have been in most of the larger jobs, because the difficulty of orientation was underestimated. It is thought that the use of 1/20,000 photos and the preparation of simple mosaics would aid a similar operation should the need arise in the future.

More use of natural features as unit boundaries.--The infestation affected only the timber on the ridgetops. In order to avoid spraying a great deal of brushland and timber that was not infested, boundaries were in some cases drawn midway down the slopes. Although it would have entailed spraying these noninfested areas, strict use of creeks and rivers as boundaries would have made the job easier for the pilots.

Better marking of boundaries.--Perhaps the need for extension of boundaries to distinct natural features might have been reduced if better boundary markers were used. Standard techniques, such as the use of long strips of butcher paper in clearings, might have been useful.

Additional ground-to-air communication

Under circumstances in which ground-to-air communication is available, a few more men with radios, particularly in widely separated parts of large units, might be used to some advantage.

Prompt detection

This infestation was caught in a fairly short period, yet it had already caused damage amounting to many thousands of dollars. Constant watchfulness and prompt reporting of unusual forest insect activity will go far toward minimizing future outbreaks of this nature.

Summary

On July 31 and August 1 and 2, 1956 an aerial spraying operation was carried out for control of an infestation of the Douglas-fir tussock moth, Hemerocampa pseudotsugata McD., in Calaveras and Tuolumne Counties, California. Seven separate units were sprayed, totalling nearly 10,000 acres. The insecticide used was DDT in diesel oil.

Private landowners, the California State Division of Forestry, and the U. S. Forest Service cooperated on the project. Technical assistance was furnished by the California Forest and Range Experiment Station.

The infestation, detected in 1955, was watched closely to determine if heavy 1956 damage appeared imminent. Surveys indicated that it would be, and the spray was applied. Postcontrol appraisals, based primarily on assessment of feeding damage and an intensive search for new egg masses, indicate that satisfactory control was achieved.